

Claims

What is claimed is:

1. An amplifier circuit for receiving an input signal for amplification comprising:
 - an input port for receiving a RF input signal;
 - an output port for providing a RF output signal therefrom that is an amplified version of the RF input signal;
 - a control port for receiving a control signal;
 - a supply voltage input port for receiving a supply voltage;
 - a regulator circuit for receiving the supply voltage and for providing a regulated supply voltage in dependence upon at least one of a temperature of the amplifier circuit, the supply voltage, and the regulated supply voltage, where at least one of the temperature signal, the supply voltage and the regulated supply voltage are provided to the regulator circuit using a direct feedback path;
 - at least a first amplification stage and a second amplification stage, the at least a first amplification stage and the second amplification stage coupled to at least one of the supply voltage and the regulated supply voltage, the first amplification stage for receiving one of a signal derived from the RF input signal and the RF input signal and for providing a first amplified signal, to the second amplification stage, the second amplification stage for amplifying a signal derived from the first amplified signal and the first amplified signal to form the RF output signal.
2. A power amplifier circuit according to claim 1, comprising a temperature sensing circuit for sensing a temperature of the power amplifier circuit and for providing a temperature signal in dependence thereon, the regulator circuit for receiving the temperature signal and for adjusting the regulated supply voltage in dependence thereon.
3. A power amplifier circuit according to claim 2, comprising a voltage sensing circuit for sensing a potential of the supply voltage and for providing a sense signal in dependence thereon, the sense signal for being received by the regulator circuit for adjusting the regulated supply voltage in dependence thereon.

4. A power amplifier circuit according to claim 3, wherein the regulator circuit comprises a FET having one of the drain and source terminals coupled to the supply voltage input port for receiving the supply voltage and the other of the drain and source terminals coupled to the first amplification stage for providing of the regulated supply voltage.
5. A power amplifier circuit according to claim 4, wherein the regulator circuit comprises an operational amplifier circuit, the operational amplifier circuit having a first input port, a second input port and an output port, the first input port thereof coupled to the control port for receiving the control signal and the output port thereof coupled to a gate terminal of the FET.
6. A power amplifier circuit according to claim 5, comprising a first summing circuit having an output port, a first input port, a second input port and a third input port, the output port thereof coupled to the second input port of the operational amplifier circuit, the first input port thereof coupled to one of the drain and source terminals of the FET for receiving the regulated supply voltage, the second input port thereof coupled to the voltage sensing circuit for receiving the sense signal, and the third input port thereof coupled to the temperature sensing circuit for receiving the temperature signal therefrom.
7. A power amplifier circuit according to claim 5, comprising a feedback sense circuit disposed between one of the drain and source terminals of the FET and the second input port of the operational amplifier circuit, the feedback sense circuit for sensing the regulated supply voltage from the FET.
8. A power amplifier circuit according to claim 7, wherein the feedback sense circuit comprises a voltage divider circuit.
9. A power amplifier circuit according to claim 7, wherein the feedback sense circuit comprises an amplitude shifting circuit.

10. A power amplifier circuit according to claim 7, wherein the feedback sense circuit is integrated on a same die as the power amplifier circuit.
11. A power amplifier circuit according to claim 3, wherein the voltage regulator circuit is integrated on a same die as the power amplifier circuit.
12. A power amplifier circuit according to claim 1, comprising a detector circuit having an input port coupled to the power amplifier circuit output port for determining a RF output signal power level and having an output port for providing an output level signal to at least one of the first amplification stage and the second amplification stage.
13. A power amplifier circuit according to claim 1, comprising a detector circuit having an input port coupled to the power amplifier circuit output port for determining a RF output signal power level and having an output port for providing an output level signal to the first amplification stage.
14. A power amplifier circuit according to claim 1, comprising a detector circuit having an input port coupled to the power amplifier circuit output port for determining a RF output signal power level and having an output port for providing an output level signal to the second amplification stage.
15. A power amplifier circuit according to claim 1, comprising a detector circuit having an input port coupled to the power amplifier circuit output port for determining a RF output signal power level and having an output port for providing an output level signal.
16. A power amplifier circuit according to claim 12, wherein the detector circuit is integrated on a same die as the power amplifier circuit.

17. A power amplifier circuit according to claim 12, wherein the detector circuit comprises at least a difference amplifier circuit having a first input port, a second input port and an output port, the first input port coupled to the detector circuit input port and the second input port for receiving a current mirrored from the RF output signal current.

18. A power amplifier circuit according to claim 17, wherein the detector circuit comprises a second summing circuit having at least an input port and an output port, the at least an input port thereof coupled to the output port of the at least a difference amplifier circuit, the output port thereof coupled to at least one of the first amplification stage and the second amplification stage.

19. A power amplifier circuit according to claim 18, wherein the detector circuit comprises:

at least a sense transistor having one of the emitter and collector terminals thereof coupled to ground and the other one of the emitter and collector terminals coupled to the second input port of the at least a difference amplifier circuit;

at least a sense resistor disposed in parallel with the first and second input ports of the at least a difference amplifier circuit; and,

a mirror transistor, the mirror transistor having one of the emitter and collector terminals thereof coupled to ground and the other one of the emitter and collector terminals coupled to the input port of the detector circuit, a base terminal of the current mirror transistor is coupled to a base terminal of the at least a sense transistor, where the mirror transistor is

for current mirroring RF output signal current.

20. A power amplifier circuit according to claim 1, wherein each amplification stage comprises at least a transistor having one of the emitter and collector terminals coupled to one of the supply voltage and regulated supply voltage and the other one of the emitter and collector terminals coupled to ground.

21. A power amplifier circuit according to claim 20, wherein each amplification stage comprises at least a current source coupled to a base terminal of the at least a transistor.
22. A power amplifier circuit according to claim 21, wherein the at least a current source is integrated on a same die as the power amplifier circuit.
23. A power amplifier circuit according to claim 1, comprising a capacitor disposed between the first amplification stage and the second amplification stage.
24. A power amplifier circuit according to claim 3, wherein the voltage sensing circuit and the temperature sensing circuit and the first amplification stage and the second amplification stage are integrated on a same die.
25. A method of operating a multi stage amplifier circuit comprising the steps of:
receiving a RF input signal;
receiving a supply voltage;
receiving a control signal;
receiving at least one of a temperature signal related to a temperature of the amplifier circuit and a sense signal related to the supply voltage;
regulating the received supply voltage to form a regulated supply voltage in dependence upon the received at least one of temperature signal and sense signal;
providing a first amplification stage having a first gain;
providing a second amplification stage having a second gain;
providing the regulated supply voltage to at lease one of the first amplification stage and the second amplification stage; and,
amplifying one of a signal derived from the received RF input signal and the received RF input signal using the first amplification stage and the second amplification stage to form a RF output signal that is an amplified version of the one of a signal derived from the received RF input signal and the RF input signal.

26. A method according to claim 25, wherein the first amplification stage is compensated for temperature and supply voltage fluctuation and the second amplification stage is compensated for control signal.

27. A method according to claim 25, wherein the first amplification stage is compensated for temperature and the second amplification stage is compensated for control signal and supply voltage fluctuations and temperature.

28. A method according to claim 25, wherein the first amplification stage is compensated for temperature and the second amplification stage is compensated for control signal and temperature.

29. A method according to claim 25, comprising the step of varying of the regulated supply voltage in dependence upon the control signal.

30. A method according to claim 25, comprising the step of varying of the first gain in dependence upon the control signal.

31. A method according to claim 25, comprising the step of varying of the second gain in dependence upon the control signal.

32. A method according to 20, wherein the step of receiving of a regulated supply voltage comprises the step of varying the regulated supply voltage in dependence upon the temperature signal.

33. A method according to claim 25, wherein the step of receiving of a regulated supply voltage comprises the step of varying the regulated supply voltage in dependence upon the sense signal.

34. A method according to claim 25, comprising the step of varying the first gain of the first amplification stage in dependence upon the sense signal.

35. A method according to claim 25, comprising the steps of:
receiving the regulated supply voltage;
summing the received portion of the regulated supply voltage and the sense signal
and the temperature signal; and,
varying the regulated supply voltage in dependence upon the step of summing.
36. A method according to claim 25, comprising the steps of:
detecting the RF output signal power level to provide an output level signal; and,
providing the output level signal to the first amplification stage.
37. A method according to claim 36, comprising the step of varying the first gain of
the first amplification stage in dependence upon the output level signal.
38. A method according to claim 36, wherein the step of detecting comprises the steps
of:
current mirroring the RF output signal current to form a RF output signal mirror
current; and,
logarithmically amplifying the RF output signal mirror current to provide the
output level signal to the first amplification stage.
39. A method according to claim 25, comprising:
detecting the RF output signal power level to provide an output level signal; and,
providing the output level signal to the second amplification stage.
40. A method according to claim 39, comprising the step of varying the second gain
of the second amplification stage in dependence upon the output level signal.
41. A method according to claim 39, wherein the step of detecting comprises the steps
of:

current mirroring the RF output signal current to form a RF output signal mirror current; and,

logarithmically amplifying the RF output signal mirror current to provide the output level signal to the second amplification stage.

42. A method according to claim 39, wherein the step of detecting comprises the steps of:

detecting a first RF output signal power level to provide a first output level signal;
detecting a second RF output signal power level to provide a second output level signal;

summing the detected first output level signal and the detected second output level signal to form a summed signal; and,

providing the output level signal in dependence upon the summed signal.

43. A method according to claim 39, wherein the step of detecting comprises the steps of:

providing a first resistor having a first resistance;
detecting a first mirror current from the RF output current using the first resistance of the first resistor;

providing a second resistor having a second resistance;
detecting of a second mirror current from the RF output using the second resistance of the second resistor;

summing the detected first mirror current and the detected second mirror current to provide a summed signal; and,

forming the output level signal in dependence upon the summed signal.

44. A method according to claim 25, comprising the step of varying the first gain and the second gain to other than vary output power of the RF output signal.